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Title: Fabrication of MQX1 Bus Duct Assemblies at LBNL

1. PURPOSE

The purpose of this document is to identify the steps that will be necessary to fabricate the MQX1 bus ducts at LBNL. These assemblies will be shipped to the DFBX Subcontractor for integration into the completed DFBX.

2. SCOPE

This document is limited to the fabrication and test of the MQX1 Bus Duct Assemblies at LBNL. The work is envisioned to be performed in two separate buildings at LBNL.

3. REFERENCE DOCUMENTS

4. ACTIVITIES IN B46

The conductors will be prepped and potted into the lambda plug assembly in B46. The detailed list of tasks include the following. These procedures are developed as a result of the Lambda Plug R&D effort.

4.1. Cut Inner s/c to length – 4 lengths each about 92 inch long
4.2. Cut copper cable to length – 4 lengths each about 92 inch long
4.3. Clean region for solder filling lambda plug area
4.4. 2 inch long solder fill all 8 cables about 45 inch from one end
4.5. Clean, remove flux from 8 cables
4.6. solder one s/c cable to one copper cable – thin edge of one to thick edge of the other
4.7. clean, remove flux and grit blast solder region
4.8. Repeat steps 6 and 7 for the remaining cables
4.9. Make 5 inch long solder connection between s/c and copper cable 11 inch from seal area toward feedbox end.
4.10. Repeat step 9 for second cable.
4.11. Kapton wrap from solder seal 11 inch towards 45 inch end (use a double wrap of .002 inch film, 3/8 inch wide, with a 50% overlap)
4.12. Kapton wrap from solder seal 18 inch towards other end (use a double wrap of .002 inch film, 3/8 inch wide, with a 50% overlap)
4.13. Cut 24 pc's of corrector wire – 106 inch long each
4.14. Remove 2 inch length of Kapton from each end and also from seal area 45 inch from one end
4.15. Clean and grit blast seal section
4.16. Prepare G-10 Plug for potting
4.17. Insert conductors and seal the magnet end. **Need fixture to hold long conductors and plug**

4.18. Attach fitting to plug and insert assembly in potting chamber. **Need tooling**
4.19. Perform Stycast injection
4.20. Hipot conductors – 5 kV with neighbors at ground potential. Use Teflon insulation tube as needed.
4.21. Dunk plug into LN 3 times
4.22. Vacuum Leak test plug after warming and drying
4.23. Prepare SS flange for potting
4.24. Prepare G-10 plug for potting
4.25. Insert plug into flange and pot magnet side with Stycast. **Need tooling**
4.26. Pot DFBX side with Stycast epoxy **Need tooling.**
4.27. Dunk into LN 3 times **Need a dunking holder**
4.28. Vacuum leak test after warming and drying **Use the 60 inch long pipe cover being designed by Scott.**
4.29. Stamp S/N on flange
4.30. Package and ship to B 77 along with traveler.

5. ACTIVITIES IN B77

The bus duct assemblies will be completed in the B77 assembly shop. The procedures listed here will be finalized in a full-length mockup.

5.1. Verify vacuum leak rate
5.2. Install lambda plug flange and Retaining Ring into assembly fixture. Rotate the lambda plug to proper orientation. **Fixture needed.**
5.3. Form conductors emerging from the lambda plug to the approximate proper radius. Clamp to maintain the bend. **Tooling needed.**
5.4. Slip large radius elbow over conductors into position. Clamp in position. **Backing ring needed to protect the conductors. Fixture needed to get proper orientation.**
5.5. Make 5 inch long solder joints between cables in each bus in the center of "vertical" run. Tin each conductor first. Clean Cable and solder joints after soldering with Acetone and Isopropyl Alcohol 50/50 mixture to remove the solder flux. Dry Cable with house compressed air. **Solder fixture needed.**
5.6. Insulate individual cable conductors. Use a double wrap of .002 inch Kapton film, 3/8 inch wide, with a 50% overlap **Hand wrapping needed**
5.7. Install 0.06 inch thick G-10 strip spacers between insulated conductors.
5.8. Apply Kapton ground wrap over the entire conductor bundle in the "vertical" section. Use a double wrap of .002 inch Kapton film, 3/8 inch wide, with a 50% overlap.
5.9. Apply a wrap of Kevlar tape over the ground wrap in 8 above.
5.10. Install 2 spiders in the vertical section. Use G-10 split clamps on either side of a spider to keep it from moving. **Spiders have a .03 inch radial clearance inside the pipe**
5.11. Slip "vertical" pipe section containing the 11/2 inch pipe and KF flange over the conductor into position. Ensure proper orientation of the KF flange. Clamp in position. **Fixture needed? Backing ring needed to protect the conductors.**

5.12. Form the conductors to make the bend to the "horizontal" section. Clamp to maintain the bend. **Need bend tooling.**
5.13. Apply Kapton ground wrap over the entire conductor bundle around the corner and 4 inch into the horizontal section. Use a double wrap of .002 inch Kapton film, 3/8 inch wide, with a 50% overlap.
5.14. Apply a wrap of Kevlar tape over the ground wrap in 13 above.
5.15. Slip the short radius elbow into position. Clamp in position. **Backing ring needed to protect the conductors. Fixture needed to get proper orientation.**
5.16. Install 1 spider about 3 inch into the horizontal section. Use G-10 split clamps on either side of the spider to keep it from moving.
5.17. Trim the conductors to length. For the cable conductors, measure, mark, and unwrap Kapton to allow the conductors to be separately tinned at the mark and cut. Rewrap the Kapton.
5.18. Install Teflon tubing over the individual conductors with a minimum 1 inch overhang past the end of each conductor.
5.19. Install the horizontal section that consists of pipe, bellows, and end cap with restraint. Clamp in position. **Backing ring needed to protect the conductors. Fixture needed to get proper orientation.**
5.20. Hipot conductors to 5 kV in air.
5.21. Perform closeout welding. Use GTAW process. Use shielding gas and employ a skipping technique with intermediate cooling with "cool gun" to minimize heat input and control distortion. Use ER308L filler wire if needed. Fill out weld log.
5.22. Perform dimensional check of bus duct piping, or verify with Go-no fixture.
5.23. Perform room temperature leak check of closeout welds. Leak rate to be less than 1×10^{-9} atm cc/sec (helium)
5.24. Perform hipot test of conductors to 5 kV in air.
5.25. Pump and purge magnet side of assembly with helium and repeat hipot test to 2 kV in helium.
5.26. Dunk the magnet end of the welded assembly into LN 5 times. Allow about 1 hour in the LN, followed by a 1 hr warm up in heated air for each cycle.
5.27. Perform leak test of closeout welds. Leak rate to be less than 1×10^{-9} atm cc/sec (helium)
5.28. Perform rate of rise test on lambda plug, both directions.
5.29. Pressure test the magnet side of the lambda plug to 370 psig at room temp with dry nitrogen gas.
5.30. Repeat leak check of closeout welds. Leak rate to be less than 1×10^{-9} atm cc/sec (helium)
5.31. Repeat rate of rise test, both directions
5.32. Pressure test the magnet side of the lambda plug to 370 psig at LN temp with helium gas.
5.33. Repeat rate of rise test, both directions
5.34. Repeat hipot test, step 24
5.35. Attached "pressure-tested" tag to magnet end of assembly
5.36. Label the individual corrector busses.
5.37. Wrap the individual main conductors with Kapton film. Use a double wrap of .002 inch Kapton film, 3/8 inch wide, with a 50% overlap. Cover with a close-fitting Teflon tube.

5.38. Package with completed traveler for shipment to DFBX Subcontractor. Fill both sides of assembly with dry nitrogen gas at a slight positive pressure.